

CHAPTER 20

Pulse Oximetry

KEY TEACHING POINTS

- Pulse oximetry rapidly measures the patient's arterial oxygen saturation, a finding that is more sensitive than cyanosis and one that provides vital information independent of the patient's respiratory rate.
- Abnormally low oxygen saturation readings predict mortality in hospitalized patients, detect hepatopulmonary syndrome in patients with chronic liver disease, and increase probability of pneumonia in patients with cough and fever.
- Limitations of oximetry are its failure to detect hypercapnia and problems of poor oxygen delivery (anemia, low cardiac output). Oximetry readings are not accurate in patients with carbon monoxide poisoning or methemoglobinemia.

I. INTRODUCTION

Pulse oximetry measures the arterial oxygen saturation rapidly and conveniently. It is regarded the fifth vital sign,^{1,2} although some clinicians argue that pulse oximetry is a diagnostic test, not a physical sign, because it requires special equipment. Measurement of oxygen saturation, however, is no different from the other vital signs whose measurement requires a thermometer, sphygmomanometer, or stopwatch.

Takuo Aoyagi of Japan discovered the basic principle of pulse oximetry—pulsatile transmission of light through tissue depends on the patient's arterial saturation—in the mid-1970s.³ The first pulse oximeters were successfully marketed in the 1980s.⁴

II. THE FINDING

Measurements are obtained by using a self-adhesive or clip-type probe attached to the patient's finger, forehead, or ear.⁵ The oximeter makes several hundred measurements each second and then displays an average value based on the previous 3 to 6 seconds, a value that is updated about every second.⁶ Although the digital display of pulse oximeters creates a sense of precision, studies show that, between oxygen saturation levels of 70% and 100%, pulse oximeters are only accurate within 5% (i.e., ± 2 standard deviations) of measurements made by in vitro arterial blood gas analysis using co-oximetry.^{4,7,8}

The most common causes of inadequate oximeter signals are poor perfusion (due to cold or hypotension) and motion artifact. The clinician can sometimes correct these problems and thus improve the signal by warming or rubbing the patient's hand, repositioning the probe, or resting the patient's hand on a soft surface.⁶ If inadequate signals persist, the clinician should try obtaining measurements with the clip probe attached to the lobule or pinna of the patient's ear.

In patients with hemiparesis, the results of pulse oximetry on the right and left sides of the body are the same.⁹

III. CLINICAL SIGNIFICANCE

A. ADVANTAGES OF PULSE OXIMETRY

As a sign of low oxygen levels, pulse oximetry is superior to the physical sign of cyanosis, because oximetry is more sensitive and because readings do not depend on the patient's hemoglobin level (see [Chapter 9](#)). Consequently, pulse oximetry has become indispensable in the monitoring of patients in emergency departments, recovery and operating rooms, pulmonary clinics, and intensive care units, where measurements often reveal unsuspected oxygen desaturation, leading to changes in diagnosis and treatment.⁵ Oxygen therapy prolongs survival of some hypoxemic patients, such as patients chronically hypoxemic from lung disease.^{10,11} Presumably, oxygen therapy benefits patients with acute hypoxemia as well.

In hospitalized patients, an O₂ saturation of less than 90% predicts hospital mortality (LR = 4.5; [EBM Box 20.1](#)). As a diagnostic sign, an O₂ saturation of less than 96% increases the probability of hepatopulmonary syndrome in patients with chronic liver disease (LR = 6.7), and an O₂ saturation of less than 95% increases the probability of pneumonia in patients with cough and fever (LR = 3.1). The use of pulse oximetry to diagnose aspiration in patients with stroke (during swallowing) is discussed in [Chapter 60](#).

B. LIMITATIONS OF PULSE OXIMETRY^{4,5,7,18,19}

Because pulse oximetry readings indicate only the degree of oxygen saturation of hemoglobin, they fail to detect problems of poor oxygen delivery (e.g., anemia, poor cardiac output), hyperoxia, and hypercapnia. Other limitations of pulse oximetry measurements are discussed below.

1. DYSHEMOGLOBINEMIAS

The pulse oximeter interprets carboxyhemoglobin to be oxyhemoglobin and therefore seriously underestimates the degree of oxygen desaturation in patients with carbon monoxide poisoning. In patients with methemoglobinemia, the pulse oximetry readings decrease initially but eventually plateau at around 85%, despite true oxyhemoglobin levels that continue to decrease to much lower levels.

2. DYES

Methylene blue causes a spurious decrease in oxygen saturation readings. Darker colors of nail polish reduce oxygen saturation readings, although the error is small with modern oximeters.^{20,21} Even so, clinicians should remove all pigments from the patient's fingers before pulse oximetry (a procedure that may also reveal additional nail findings). Hyperbilirubinemia and jaundice do not affect oximeter accuracy.

3. LOW PERFUSION PRESSURE

In patients with hypotension or peripheral vascular disease, the arterial pulse may be so weak that the pulse oximeter is unable to pick up the arterial signal, thus making measurements difficult or impossible.

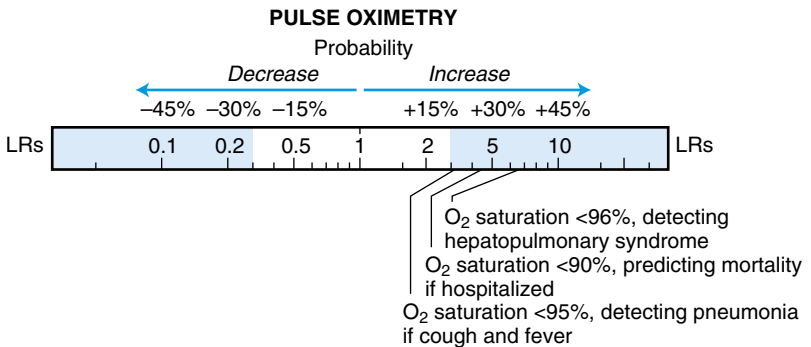
**EBM BOX 20.1***Oxygen Saturation by Pulse Oximetry**

Finding (Reference)	Sensitivity (%)	Specificity (%)	Likelihood Ratio [†] if Finding Is	
			Present	Absent
Predicting Hospital Mortality in Hospitalized Patients				
Oxygen saturation <90% ^{12,13}	21-39	87-97	4.5	0.8
Detecting Hepatopulmonary Syndrome in Patients With Chronic Liver Disease				
Oxygen saturation <96% ¹⁴	39	94	6.7	0.6
Detecting Pneumonia in Outpatients With Cough and Fever				
Oxygen saturation <95% ¹⁵⁻¹⁷	33-52	80-86	3.1	0.7

*Diagnostic standard: For *hepatopulmonary syndrome*, triad of cirrhosis, intrapulmonary shunting by contrast echocardiography, and arterial alveolar to arterial oxygen gradient >20 mm Hg; for *pneumonia*, chest radiography.

[†]Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.

[Click here to access calculator](#)



4. EXAGGERATED VENOUS PULSATIONS

In patients with right-sided heart failure or tricuspid regurgitation, the oximeter may mistake the venous waveform for the arterial one, leading to spuriously low oxygen saturation readings.

5. AMBIENT LIGHT

Excessive ambient light has long been felt to affect oximeter readings, although one study comparing various types of lamps (fluorescent, incandescent, infrared heat, quartz-halogen, and bilirubin lamps) failed to show any clinically significant effect on oximeter readings.²²

The references for this chapter can be found on www.expertconsult.com.

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